

Cathodoluminescence study of calcite in Martian meteorite (Dhofar 019)

Tadahiro Nakazato (1), Masahiro Kayama (1), Hirotsugu Nishido (1), Kiyotaka Ninagawa (2), Arnold Gucsik (3) and Szaniszló Bérczi (4)

(1) Research Institute of Natural Sciences, Okayama University of Science 1-1 Ridaicho, Okayama, 700-005, Japan (E-mail: nakazato@rins.ous.ac.jp) (2) Department of Applied Physics, Okayama University of Science 1-1 Ridaicho, Okayama, 700-005, Japan (3) Max Planck Institute for Chemistry, Department of Geochemistry, Mainz, Germany (4) Eötvös University, Institute of Physics, Dept. G. Physics, Cosmic Materials Space R. Group, H-1117 Budapest, Hungary.

Introduction

Dhofar 019 found in the desert of Oman is classified as an olivine-bearing basaltic shergottite. It consists of subhedral grains of pyroxene (pigeonite and augite), olivine, and feldspar mostly converted to maskelynite and minor phases, with terrestrial secondary minerals. Calcite occurs in it as a small grain coexisted with merrillite and olivine, and interstitial filling in olivine cracks. Although carbonates have been recognized in several Martian meteorites, most of the minerals have been interpreted as a weathering product after the fall on the Earth. The calcite in Dhofar 019 meteorite has been referred to a secondary mineral [1], whereas it has not been investigated in detail. In this study, cathodoluminescence (CL) and Raman spectroscopy clarify the calcite formation as Martian origin in Dhofar 019.

Samples and methods

Two polished thin sections of Dhofar019 meteorite were employed for CL and Raman measurements. Color CL images were obtained by Luminoscope ELM-3R (Nuclide) at accelerating voltage of 15 kV and beam current of 0.5 mA. The CL spectra were collected using a cathodoluminescence scanning microscopy (SEM-CL), SEM (JEOL: JSM-5400) combined with a grating monochromator (OXFORD: MonoCL2), in the range from 300 to 800 nm at accelerating voltage of 15 kV and beam current of 1.0 nA. The Laser Raman spectroscopy was carried out using a NRS-2100 (JASCO) with an Ar laser of 514.5nm wave length.

Results and discussion

Three modes occurrence can be identified; filling in olivine (Vein) and small grains coexisted with olivine (S) and merrillite (L). The calcite show a dull orange emission with homogeneous feature in color CL images. CL spectra of the calcite in Dhofar019 exhibit two broad peaks at around 420nm related to defect center and at around 620 nm assigned to Mn^{2+} impurity center (Fig.1). CL of terrestrial calcite is usually represented by a pronounced red to orange emission due to Mn^{2+} activator with faint or no blue emission. This fact indicates that the calcite in Dhofar019 has a high density of the defect in its lattice, suggesting different genetic condition from terrestrial

calcite. Raman spectra of terrestrial calcite are characterized by relatively sharp peaks at around 154 cm^{-1} , 281 cm^{-1} and 1089 cm^{-1} , whereas calcite in Dhofar019 gives very weak Raman peaks at around 142 cm^{-1} , 264 cm^{-1} and 1085 cm^{-1} , with unambiguous peak shift by comparison with the terrestrial calcite (Fig.2). Shock pressure of this meteorite has been estimated at approximately 40 GPa on the basis of formation condition of the maskelynite. These facts imply that the calcite in Dhofar 019 is Martian origin.

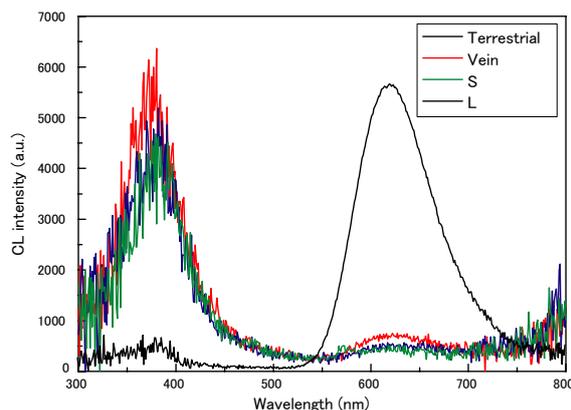


Fig. 1 CL spectra of calcite in Dhofar019 and terrestrial one.

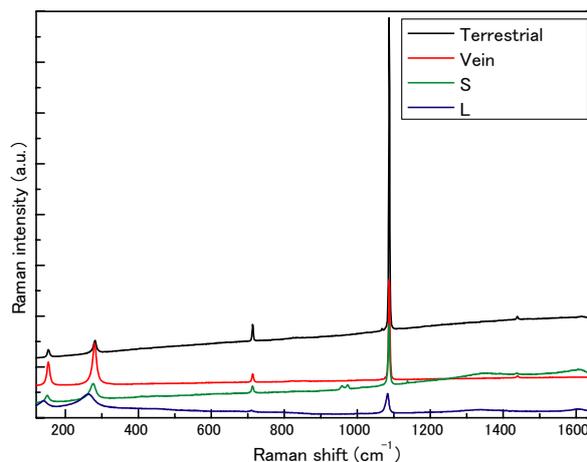


Fig. 2 Raman spectra of calcite in Dhofar019 and terrestrial one.

References

- [1] <http://curator.jsc.nasa.gov/atmet/mmc/index.cfm>